DOCUMENT RESUME

ED 153 154 CG 012 503

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TITLE Instructional Design Strategies for Rule Attainment in Fifth-Grade Students.
PUB DATE Aug 77
NOTE 13p.; Paper presented at the Annual Convention of the American Psychological Association (San Francisco, California, August 26-30, 1977)

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS Children; *Concept Teaching; *Educational Strategies; *Instructional Design; *Integrated Curriculum; Intermediate Grades; *Learning Processes; Lesson Plans; Research Projects
IDENTIFIERS *Rule Attainment

ABSTRACT

Fifth-graders read lessons dealing with a geometry rule. Half of the subjects also received pre-instruction on the concepts related in the rule prior to studying the rule itself. The pre-instruction presented the concepts in either a logical order with relationships among the concepts stressed (integrative lesson) or a random order with no mention of how the concepts were related (non-integrative lesson). Learning was measured on a rule attainment test designed to assess subjects knowledge of and ability to apply the rule. Results showed that only subjects receiving pre-instruction on the concept performed significantly better than a control group that received no instruction on either the concepts or the rule. There was no significant difference in performance between subjects reading integrative concept-teaching lessons and subjects reading non-integrative concept-teaching lessons. (Author)

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ED153154

INSTRUCTIONAL DESIGN STRATEGIES FOR RULE ATTAINMENT IN FIFTH-GRADE STUDENTS

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A paper presented at the meeting of the American Psychological Association, San Francisco, August 1977

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Instructional Design Strategies for Rule Attainment in Fifth-Grade Students

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Rule attainment is the learning of a particular relationship between two or more concepts. It is a two step process, in that both the concepts related in the rule and the nature of the relationship among the concepts must be mastered. As much of the content presented in the classroom, and most of what is retained after instruction, is in the form of generalizable rule statements, knowledge of the types of instructional procedures that are most facilitative in rule acquisition is of importance to educators.

Unfortunately, research on instructional design strategies for facilitating rule acquisition is not extensive and has primarily focused on variables related to the practice or teaching examples (correct applications) of the rule that are presented for the learner. For example, Gagné and Wiegand (1968) found that very simple rules can be learned from a rule statement and a single example of the rule's correct application. However, work by Anderson (1970) suggests that the use of only one teaching example may be inadequate for complex rules. Traub (1966) reported that using heterogeneous teaching examples that illustrated the scope of the rules applicability was in general more facilitative than using homogeneous teaching examples representative of only a restricted range of applicability.

Tennyson and Tennyson (1975) combined Traub's approach of providing heterogeneous rule examples with several design strategies found to be effective in concept learning instruction in a pair of studies in which tenth-grade students learned two related transformational syntax rules. The rules were presented through a combination of rule statements, heterogeneous rule examples and nonexamples (incorrect applications of the rule), and analytical explanations of how the rules were applied in the examples. Results showed that students performed significantly better when the two rules were presented simultaneously (with examples of one rule serving as nonexamples for the second) rather than successively, when rule examples were heterogeneous rather than homogeneous, and when analytical explanation was provided with the examples and nonexamples.

It can be concluded from the work of Traub (1966) and Tennyson and Tennyson (1975) that providing heterogeneous rule examples and nonexamples with some analytical explanation facilitates rule acquisition. Yet it seems unlikely that this strategy would be effective if, prior to instruction, the concepts related by a rule as well as the rule itself were unfamiliar to the learner. Indeed, Ausubel and Robinson (1969), Gagné (1970), and Klausmeier, Ghatala, and Frayer (1974) have each postulated that a major initial condition for rule acquisition is mastery of the concepts related by the rule.

Some support for the contention that the component concepts of a rule must be mastered before the rule itself can be attained comes from a descriptive assessment of the conceptual development of 800 school children reported by Klausmeier, Sipple, and Allen (Note 1). The authors found that without knowledge of the key concepts presented in a rule the majority of children studied were unable to answer questions correctly that tested their knowledge of and ability to apply the rule. However, this research involved only an assessment of students' knowledge; no attempt was made to

teach either concepts or rules to the participants.

One purpose of the present study was to experimentally test the hypothesis that knowledge of the concepts related in a rule is necessary for rule attainment. Specifically it was predicted that pre-instruction on the concepts related in a rule coupled with instruction on the rule itself would be more facilitative in promoting rule attainment than rule instruction alone.

A second purpose of the present research was to investigate the importance of the manner in which the component concepts are presented. If as Gagné (1970) and Klausmeier, Ghatala, and Frayer (1974) seem to suggest, the critical element is mastery of each component concept, then presenting the concepts in a random order as isolated bits of information should be equally effective as presenting the concepts in a logical order as related material. Yet it would seem that if the concepts are introduced as isolated entities the learner may assume that they bear no relationship to one another and then be unprepared to deal with the concepts in combination when they are presented together as a rule. This difficulty could then inhibit rule attainment. Hence it was also predicted that pre-instruction on the concepts related in a rule that presented the concepts in a logical order and stressed relevant relationships among the concepts (integrative lesson) would be more facilitative in promoting rule attainment than pre-instruction in which the concepts were presented in a random order and relationships among the concepts were not explicity stated (non-integrative lesson).

METHOD

Subjects

Subjects were 82 fifth-grade students, 44 males and 38 females, from two urban elementary schools in the Washington, D.C. area. They were judged to be of average general ability and socioeconomic status,

and they had not previously studied the concepts or rule presented as the learning task of the experiment as part of their formal school curriculum.

Subjects were grouped into three strata (high, medium, and low) on the basis of reading achievement scores obtained on the California Test of Basic Skills administered during the fall of the school year. The mean achievement score for all subjects was 31.0. Mean achievement scores for the high, medium, and low strata were 37.3, 29.8, and 22.5, respectively. An achievement score of 23.5 corresponded to a grade equivalent of 5.0. Thus the average subject was somewhat above grade level in reading ability. Subjects were randomly assigned within stratification level to an experimental condition.

Materials

Treatment Materials. The rule used as the subject matter in the learning task was taken from the field of geometry. It was stated as follows: "If the three angles of a triangle are equal in number of degrees, the sides of the triangle are equal in length." Two types of printed, sequential lessons were developed to teach the rule. The first lesson presented the major concepts related in the rule (underlined in the rule statement above), while the second lesson presented the rule itself.

Two forms of the concept-teaching lesson, one providing integration of the concepts and the other not providing integration, were constructed. In both forms each concept was defined and illustrated with a labeled rational set of examples and nonexamples (Markle & Tiemann, Note 2). In addition, a verbal statement analyzing the presence or absence of relevant attributes accompanied each example and nonexample. The definitions, rational sets and analytic statements were the same in each form, and the forms were each 13 pages in length. At the end of each form was an identical page of review questions for subjects to use to test their mastery of the

the material presented. Subjects were encouraged to review their booklets again if they had any trouble answering the questions. Correct answers were provided on the following page.

In the concept-teaching lesson providing integration the subjects were told that the lesson dealt with a special kind of figure called a triangle, and the concept was then defined. The concepts side and angle were then immediately introduced as parts of a triangle. The lesson next proceded to teach through a definition, rational set, and analytic statements first the consetp side and then the concept angle, relating each of them back to the idea of a triangle and to each other. Finally triangle was once again introduced and defined followed by a labeled rational set of examples and nonexamples and accompanying analytic statements.

In the non-integrative lesson the concepts were presented in a random order (angle, side, triangle) and no attempt was made to relate them to one another. Subjects were merely told at the beginning of the booklet that the lesson was about three words and their job was to read the information presented about each word and try to learn it. Each concept was then presented separately through definition, rational set, and analytic statements as though it were unrelated to the other two.

The rule-teaching lesson was five pages in length. The rule was presented in a box at the top of the first page and was followed by a heterogeneous set of three examples that varied along the following irrelevant dimensions: the size of the triangle used to illustrate the rule, the spatial orientation of the triangles, and the manner in which the equivalence among the angles of the triangles was indicated. Two nonexamples, matched to the examples on irrelevant dimensions, were presented next. They were designed to illustrate the two basic cases in which the rule could not be applied correctly. Specifically, one nonexample pictured a triangle with three unequal angles and hence three sides of

unequal length. The second nonexample pictured a triangle with two equal angles and hence only two sides of equal length. The five instances together were considered to be the minimal number necessary to illustrate the range of the rules applicability. Analytical explanations of why the rules were correctly applied in the examples and incorrectly applied in the nonexamples were also provided.

Two printed placebo lessons were also prepared. The first placebo lesson dealth with the concept tree and was equal in length to the concept teaching lessons. The second placebo lesson dealt with the concept Roman numerals and was equal in length to the rule-teaching lesson.

Dependent Measure

A 20-item test designed to assess subjects' knowledge of and ability to apply the geometry rule in previously unencountered problem situations was constructed. The test was presented in a printed booklet similar in form to the lesson booklets. Instructions for completing the test were included at the beginning of the booklet. Within the instructions were several sample items, one corresponding in form to each of the different types of question formats used on the test (true-false and multiple-choice).

Experimental Conditions

Four experimental conditions which varied in the type of instruction given subjects were defined. Specifically, they were as follows:

Treatment I. Subjects read the concept-teaching lesson with integration and the rule-teaching lesson.

Treatment II. Subjects read the concept-teaching lesson without integration and the rule-teaching lesson.

Treatment III. Subjects read the placebo lesson dealing with the concept tree and the rule-teaching lesson.

Control. Subjects read the two placebo lessons.

Procedure

Prior to experimentation prepackaged sets of experimental lessons were labeled with subjects' names to insure that each subject received the appropriate lessons for the treatment to which he/she had been assigned. All experimental lessons and testing materials were administered in classroom groups, and each experimental session lasted approximately 50 minutes.

The experimenter began each teaching-testing session by explaining the purpose of the research and the general procedures to be followed. Lesson sets were then distributed, and all subjects were instructed to begin reading. After completing the first lesson, subjects were directed to begin reading the second.

After all subjects completed both lesson booklets the rule attainment test was distributed. The experimenter read the directions for the test and reviewed the sample items aloud while subjects followed along in their own test booklets. Subjects then began the test and were permitted to work on it for as long as they wished. No subject had difficulty finishing the test in the time allotted.

During the teaching-testing session the experimenter and an assistant answered any questions dealing with the pronunciation of words and the purpose of the experiment. If subjects had questions regarding the content of the lesson materials, they were directed to reread the material.

Experimental Design and Statistical Analysis

The experiment employed a 3 x 4 analysis of variance design with three levels of reading achievement and four experimental conditions. The overall analysis of variance was followed by a series of pairwise comparisons using Tukey's procedure with a significance level of .05.

RESULTS

Results of the 3 x 4 analysis of variance yielded a significant main effect for both treatment, $F(3,70) = 4.83$, $p < .01$, and reading achievement level, $F(2,70) = 3.73$, $p < .05$. The interaction was not significant.

Group means for the experimental conditions were in the predicted direction. Subjects reading integrative concept-teaching lessons and the rule teaching lesson ($M = 16.6$) scored higher than subjects reading non-integrative concept-teaching lessons and the rule teaching lesson ($M = 16.4$), who in turn scored higher than subjects only reading the rule teaching lesson ($M = 15.5$). All treatment groups scored higher than the control group ($M = 14.4$).

Pairwise comparisons among the four treatment means revealed that only subjects reading concept-teaching lessons (both integrative and non-integrative) followed by the fule teaching lesson performed significantly better on the dependent measure than control subjects. No other differences between the means were found to be significant. Clearly these results support the hypothesis that knowledge of the concepts related in a rule is necessary before the rule itself can be attained. Additionally, it appears that pre-instruction on the concepts need not be presented in a logical and integrative manner.

Examination of the means entering into the main effect for reading achievement revealed that subjects in the high group socred higher ($M = 16.4$) than subjects in the middle group ($M = 15.2$), who scored similarly to subjects in the low group ($M = 15.2$). Thus, the ability to learn from the lessons was related to reading skill, as would be expected. Pairwise differences among the means, however, were not found to be significant.

DISCUSSION

Results of the present study support the hypothesis that knowledge of the concepts related in a rule is necessary before the rule itself can be attained. Indeed, subjects given only instruction on the rule were found to perform no better than control subjects who read placebo lessons. This finding supports the positions of Ausubel and Robinson (1969), Gagné (1970) and Klausmeier, Ghatala, and Frayer (1974). Additionally, it has direct implications for the classroom setting. Teachers should ascertain that the component concepts of a rule are mastered before the rule itself is introduced.

The prediction that the concepts must be logically presented and related to each other for the information to be maximally facilitative to the learner, however, was not supported in the present research. Indeed, introducing the concepts in a random order as isolated bits of information was found to be equally effective as the more logical integrative approach. In both pre-instructional conditions subjects were able to answer correctly over 80% of the test items. Apparently, the key element is merely knowledge of the concepts; students need not be made aware explicitly of the relatedness of the concepts until they are presented together in the rule statement.

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